Building Research Establishment Digest

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Sanitary pipework: Part 2
Design of pipework

The main features of a simplified discharge system are shown in Fig 5. A discharge stack, without offsets, and with a large radius bend at its base, is connected to the underground drainage system and collects the discharges from the appliance branch discharge pipes. Self and induced siphonage in the branch pipe are controlled by the correct choice of pipe size, gradient and bends and by the appropriate number of appliances. The need for ventilating pipes is therefore avoided. Stack venting is avoided by restricting the number of appliances connected to a particular size discharge stack, by the correct design of branch/stack fittings (thereby controlling induced siphonage) and by avoiding offsets and using a large radius bend at the base of the stack (minimising back pressure effects).

The following data can be conveniently dealt with by considering branch discharge pipes and discharge stacks as separate components.

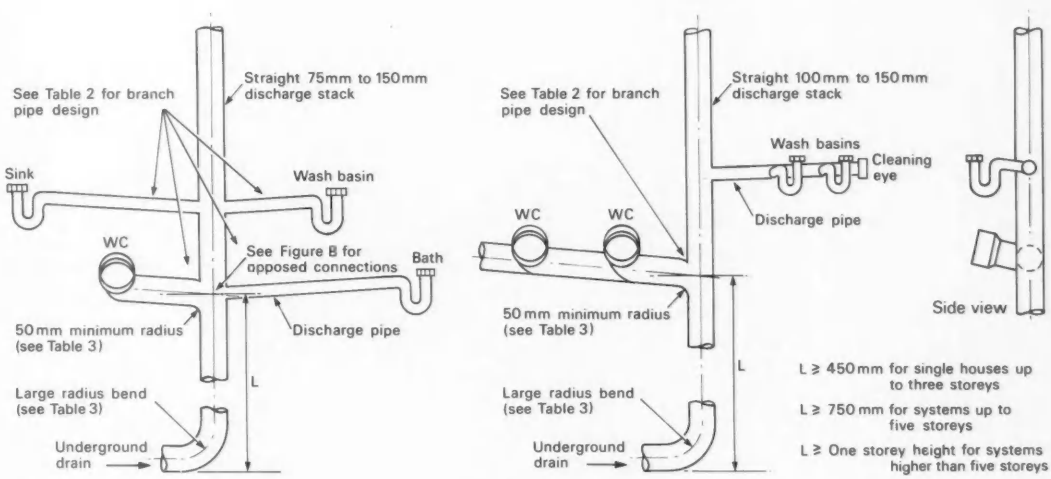
See Table 2 for branch pipe design
Straight 75mm to 150mm discharge stack
Sink
Wash basin
WC
See Figure B for opposed connections
Bath
50mm minimum radius (see Table 3)
Discharge pipe
L
Large radius bend (see Table 3)
Underground drain
(a) Single appliances
See Table 2 for branch pipe design
Straight 100mm to 150mm discharge stack
Wash basins
Cleaning eye
WC
WC
Discharge pipe
50mm minimum radius (see Table 3)
L
Large radius bend (see Table 3)
Underground drain
(b) Multiple appliances
Side view
L ≥ 450mm for single houses up to three storeys
L ≥ 750mm for systems up to five storeys
L ≥ One storey height for systems higher than five storeys

Fig 5 Simplified system – main features

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Branch discharge pipes

A summary of the requirements for branch discharge pipes is given in Table 2. In general, the pipework should be kept as short as possible, with uniform gradients and without unnecessary bends but where bends are unavoidable they should be of large radius. Access for clearing deposits and blockages is important, especially for sinks and urinals. The following notes explain this design data.

Wash basins The risk of self-siphonage is much more dependent on the design of the branch than it is for other appliances. For single basins fitted with P-traps the usual 32mm pipes normally run full and so cause self-siphonage at the end of the discharge. One remedy is to limit the length and slope of the pipe as shown in Fig 6 for a P-trap arrangement. When the basin is more than 1.7m from the stack a 32mm diameter trap with a short 32mm tail pipe can be connected to a 40 or 50mm branch pipe. This should prevent the branch from running full (which is sometimes noisy) and thus reduce the self-siphonage effects. An alternative solution is to use a resealing trap, with the 32mm branch. S-trap arrangements produce particularly severe self-siphoning conditions which can be relieved only by a suitable resealing trap or by the venting systems detailed in the Code of practice.

Ranges of wash basins generally require ventilating pipes or resealing traps, especially when S-trap arrangements are used. However, one solution avoiding these precautions, for up to four wash basins, is shown in Fig 7, using a 50mm main branch pipe. Spray tap branch pipes do not normally run full even when the branch is only 30mm diameter and trials have shown that up to eight basins can be connected to this size of pipe. However, pipes serving spray tap basins are prone to become blocked by sedimentation and regular cleaning is usually necessary.

Sinks, baths and showers These appliances are generally fitted with 40mm branch pipes and so self-siphonage effects are not significant. Also, trap refill occurs at the end of a discharge from water draining from the flat bottom of the appliance, which tops up any seal loss.

Urinals Self-siphonage does not usually occur and trap refill from the trail off of the flushing water will top up any losses. Depostion can occur very rapidly and regular cleaning may be necessary, especially in hard water areas where scaling can be severe.

Washing machines The most usual arrangement with washing machines is a vertical 40mm standpipe connected to the stack or external gully via a special P or running trap and 40mm branch. The important feature is the provision of an air gap where the washing machine hose enters the top of its standpipe to avoid siphonage during operation of the machine.

Discharge stacks

A summary of the requirements for discharge stacks is given in Table 3. In vertical pipework serving appliances on different floors means must be found to limit the effects of induced siphonage and back-pressure. These effects depend on such factors as the number and distribution of appliances, pattern of use, height of the building, dimensions of the branch and stack pipes and the design of the branch/stack connections. Diameters of 75mm, 100mm and 150mm are commonly used for

drainage stacks and these sizes have therefore been taken as the starting point for the sizing data given in Table 4.

Branch to stack connections The shape of the WC branch connection to the stack is most important as it influences induced siphonage in the stack. The recommendations in Table 4 assume that WC branch connections are swept in the direction of flow. Smaller diameter branch connections are not so critical and a swept entry is unnecessary.

Table 2 Design of branch discharge pipes

Appliance	Number of appliances	Branch pipe: Trap size *mm* and type	Branch pipe: Max. length *m*	Branch pipe: Size *mm*	Bends in branch pipe	Design precautions: Principle action to be guarded against	Design precautions: Trap design	Design precautions: Branch gradients	Design precautions: Other requirements
Wash basin	Single	32 P	1.7	32	Not more than 2 (min radius 75 mm to centre line)	Self-siphonage	Tubular	See Fig 6	Recommendations for BS 1188 wash basins with overflow. Some bottle traps will be suitable.
	Single	32 P	3.0	40	Not more than 2 (min radius 75 mm to centre line)	Self-siphonage and excessive deposition	Tubular or bottle	1° to 2½° (18 to 45 mm/m)	Connect 40 mm branch to trap with 32 mm tail pipe, 50 mm long.
	Single	32 P or S	3.0	32	Any bends to have min radius of 75 mm to centre line	Self-siphonage and excessive deposition	Resealing	1° to 2½° (18 to 45 mm/m)	See Code of Practice for vented arrangements
	Range of up to 4	32 P	3 Main 0.74 Branch	50 Main 32 Branch	None	Self and induced siphonage and excessive deposition	Tubular or bottle	1° to 2½° (18 to 45 mm/m)	Swept entry fittings at connections between 32 mm and 50 mm branches
	More than 4	32 P	10 Main 1 Branch	50 Main 32 Branch	Any bends to have min radius of 75 mm to centre line	Self and induced siphonage and excessive deposition	Resealing	1° to 2½° (18 to 45 mm/m)	Swept entry fittings at connections between 32 mm and 50 mm branches. See also Code of Practice for vented arrangements.
	More than 2	32 S	10 Main 1 Branch	50 Main 32 Branch	Any bends to have min radius of 75 mm to centre line	Self and induced siphonage and excessive deposition	Resealing	1° to 2½° (18 to 45 mm/m)	Swept entry fittings at connections between 32 mm and 50 mm branches. See also Code of Practice for vented arrangements.
Bath, Sink	Single	40 P or S	3	40	Any bends to have min radius of 75 mm to centre line	Self-siphonage and excessive deposition	Tubular or bottle	1° to 5° (18 to 90 mm/m)	Longer branches possible but noisier discharge and/or blockage may result. S-trap arrangement will also give noisier discharge.
Shower	Single	40 P or S	3	40	Any bends to have min radius of 75 mm to centre line	Self-siphonage and excessive deposition	Tubular or bottle	1° to 5° (18 to 90 mm/m)	
Washing Machine	Single	40 P or running trap	3	40	Any bends to have min radius of 75 mm to centre line	Siphonage from machine during refill	Tubular or bottle	1° to 2½° (18 to 45 mm/m)	40 mm standpipe, 600-900 mm high (depending on machine) with air gap at hose opening.
WC	Single	75 to 100 P or S	6	100	Avoid knuckle bends	Excessive deposition	–	1° min (18 mm/m)	Branch pipe size of 75 mm can be used with syphonic WCs.
	Range of up to 8	75 to 100 P or S	15	100	Avoid knuckle bends	Excessive deposition and induced siphonage	–	½ to 5° (9 to 90 mm/m)	Swept entry fittings needed between WC branches and main branch.
Urinal	Single Bowl	40 P or S	3	40	Any bends to have min radius of 75 mm to centre line	Excessive deposition	Tubular or bottle	1° to 5° (18 to 90 mm/m)	Access for cleaning important.
	Range of up to 5 bowls	40 P or S	As short as possible	50 Main 40 Branch	Any bends to have min radius of 75 mm to centre line	Excessive deposition and induced siphonage	Tubular or bottle	1° to 5° (18 to 90 mm/m)	Access for cleaning important.
	Range of stalls	65 or 75 P or S	As short as possible	65 or 75	Large radius bends	Excessive deposition	Tubular	1° to 5° (18 to 90 mm/m)	Access for cleaning important.

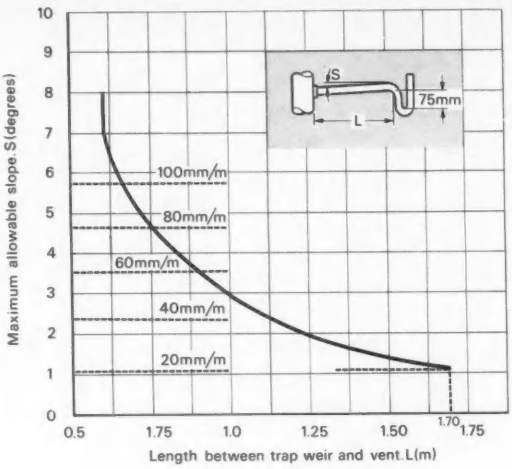

Fig 6 Design of branch pipe for single wash basin
Design curve for nominal 32mm branch pipe and 75mm seal P-traps connected to single BS wash basins. The minimum desirable slope is 20mm/m (approx 1¼°). The slopes recommended are allowable maxima but the pipes need not be fixed at exactly the gradients read off the graph.

Bend at base of stack A sharp bend at the base of the discharge stack can cause back pressure to affect the seals of the lowest branch connections. It can also cause a build-up of detergent foam especially in systems serving multi-storey dwellings. The bend should therefore be of large radius; a further precaution for buildings over five storeys high is to connect the ground floor appliances directly to the drain or manhole or to use a bend which is one size larger than the stack itself, provided this does not oversize the drain.

Opposed branch-to-stack connections In any discharge system, fully vented or simplified, the discharge from one branch connection to the stack must not be able to back up an opposed branch connection. This becomes especially critical when one of the opposed branches serves one or more WC's. Figure 8 illustrates the positions on a stack which should be avoided when a small diameter branch pipe, for example serving baths, has to be connected opposite a WC branch connection. A connection may be made level with the point where the centre lines of the WC and opposed branch coincide, but not within 200mm below it. Connections on the same side of the stack within this distance are permissible but generally are difficult to carry out in practice.

Offsets An offset in the discharge stack above the topmost connection has little effect on the performance of the system. Offsets below the topmost connection should be avoided or ventilating pipes may be required to prevent large pressure fluctuations in the stack.

Termination of discharge stack To minimise the effects in discharge stacks due to wind blowing across the roofs of tall buildings, the stack terminations should be sited away from known areas of high suction. These are usually at corners of the roofs and edges of parapets. Normal venting arrangements will not provide a remedy but a protective cowl may be of benefit.

Rainwater connections Where it is permissible for the discharge pipe system to carry rainwater, the discharge stack in a simplified system can be used provided certain precautions are taken. The roof area served by a stack should not be greater than $40m^2$ and the building should not be more than ten storeys in height. Where easy access to the roof exists, the roof gulley linking the roof to the stack should be trapped.

Table 4 gives data for discharge stack sizing for the more common arrangements; for other systems, reference should be made to the Code of practice. Table 5 gives additional information for office and public buildings to enable discharge stacks serving WC's, basins and urinals to be sized from Table 4. The four combinations of appliances given are based on the provision of two Statutory Instruments made under the Offices, Shops and Railway Premises Act 1963 and these are equated to the hydraulic equivalents of WC/basin combinations.

Neither this digest nor the Code of practice can cover every possible arrangement of pipework. For other designs, especially where a long branch pipe or venting a long range of appliances is considered, a test or mock-up is recommended. Test procedures are given in the Code of practice.

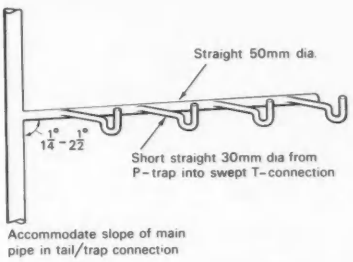

Fig 7 Design of branch pipes for up to four wash basins

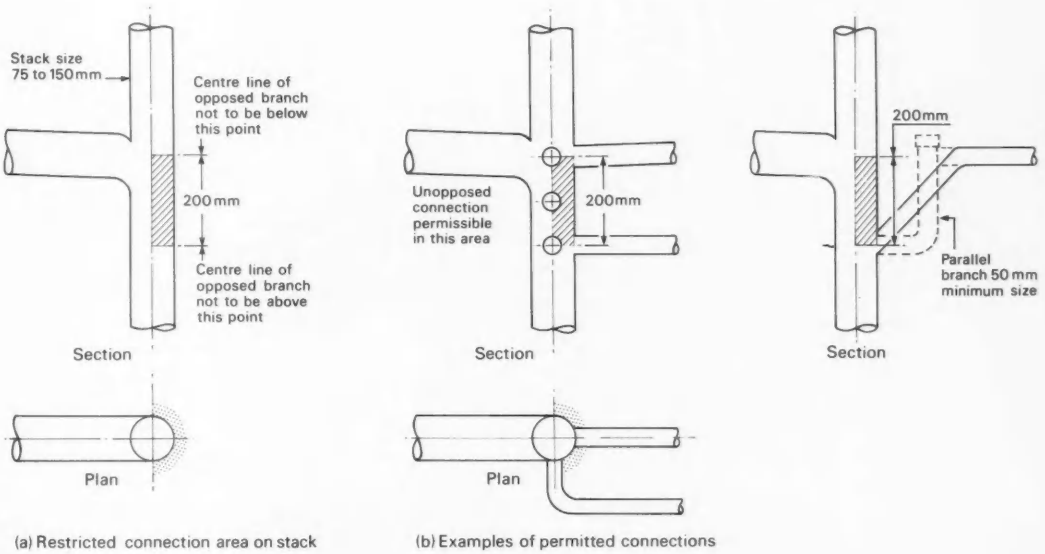

Fig 8 Opposed branch pipe connections to discharge stacks

Table 3 Design of discharge stack

Component	Action to be guarded against	Recommendations
WC (100 mm) branch connections	Induced siphonage	To be swept in direction of flow with minimum sweep radius of 50 mm (but see Note in Table 4)
Bend at base of stack	Back pressure and build up of detergent foam	Bend to be of large radius, at least 200 mm radius to centre line but preferably two 45° large radius bends. Bend can also be enlarged by one size but this may oversize the drain.
Lowest stack connection	Back pressure effects	Distance between lowest branch connection and invert of drain to be: 450 mm for single houses up to three storeys; 750 mm for multi-storey systems up to five storeys; One storey height for systems over five storeys.
Offsets	Pressure effects	Avoid offsets in wet part of stack.
Opposed branch connections	Backing up of WC branch discharge into opposed branch	Position of opposed connection to be as shown in Figure 8

Table 4 Discharge stack sizing — *stack and branch design to Tables 2 and 3*

Stack size *mm*	Use		Number of floors of appliances	Max number of appliances/floors
	Description	Interval between use *mins*		
75	Domestic	20	Up to 2	1 Domestic Group*
100	Domestic	20	Up to 10	2 Domestic Groups*
	Commercial	10	Up to 8 Up to 4	2 WCs + 2 wash basins 5 WCs + 5 wash basins
	Congested	5	Up to 8 Up to 4	1 WC + 1 wash basin 3 WCs + 3 wash basins
150	Domestic	20	Up to 30	2 Domestic Groups*
	Commercial	10	Up to 24 Up to 8	3 WCs + 3 wash basins 5 WCs + 5 wash basins
	Congested	5	Up to 24 Up to 16 Up to 8	2 WCs + 2 wash basins 3 WCs + 3 wash basins 5 WCs + 5 wash basins

*1 domestic appliance group is 1 WC, 1 sink, 1 wash basin, 1 bath (and/or shower) and 1 washing machine.

Note: For non-swept WC branch connections, with 2 groups of domestic appliances per floor:
A 100 mm stack can be used for systems up to 4 floors in height
A 150 mm stack can be used for systems up to 15 floors in height.

Table 5

WC		Urinal		Wash basin			WC		Wash basin
2	+	1	+	2	Equivalent		2	+	2
2	+	2	+	3	to:		3	+	3
3	+	3	+	4			4	+	4
4	+	4	+	5			5	+	5

Other simplified systems

Some pipework systems do not need to conform to all the requirements given under *Design basis* or to the general arrangements shown in Figure 5; for example:

Ground floor appliances not connected to the discharge stack Ground floor appliances are sometimes connected to the underground drainage system via an external gulley or, in the case of the WC, directly to the drain without a ventilating stack.

Where branch pipes discharge into a gulley, the appliance traps are not subject to significant pressure fluctuations or to drain air, and so the trap seal depth can be reduced to 40mm. However, it is preferable to fit a 75mm seal trap to a ground floor wash basin as self-siphonage losses may effectively empty the trap and so allow air to be blown through the pipework into the bathroom.

A ground floor WC can be connected directly to the drain without using a discharge stack or ventilating pipework provided that the vertical distance from the crown of the of the trap to the invert of the drain is not more than 1.5 metres. Excessive water seal losses can result if a larger vertical drop is used especially when bulky objects, such as disposable nappies, are flushed from the WC.

Stub Stacks In some areas it has become common practice to connect the domestic sanitary appliances in single-storey buildings to a short straight 100mm discharge stack with the top closed by an access fitting. This arrangement performs satisfactorily provided the distance from the crown of the WC trap to the invert of the drain is not more than 1.5 metres and the distance between the topmost connection to the stack and the invert of the drain is not more than 2 metres. However where a drain serves a number of dwellings equipped in this way, the upstream end of the underground drain should be vented either by a separate ventilating stack or by a conventional discharge stack as already described.

Ventilating valves In recent years, ventilating valves have become available which relieve negative pressures in the discharge system but prevent foul air entering the building if positive pressures occur. The valve can be incorporated into a trap (an anti-vacuum trap) or can be connected to the system as a separate component. Generally valves or anti-vacuum traps fitted to small diameter branches should only be used to relieve siphonage conditions in the branch pipe and not induced siphonage effects from the discharge stack through, say, undersizing of the stack. Larger valves can be used to ventilate the discharge stack provided they are fitted to a WC branch and/or the top of the discharge stack but manufacturers instructions must be closely followed. Design of these valves vary significantly and each must be judged on its merits; only those that have been granted Agrement certificates should be considered. When a number of homes are equipped with the ventilating valves, any common branch drain should be ventilated by an open stack at its upstream end.

Further reading

BS 5572: 1978 Code of practice for Sanitary pipework

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